

MODELLING AND SIMULATION OF FLEXIBLE PRODUCTION LINE  
FOR COIL WINDING ASSEMBLY

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## ABSTRACT

This thesis deals with modelling and simulation of flexible production line for coil winding assembly. Flexible production line is a production line capable to change any changes in different product simultaneously and continuously. The reason need of developing flexible production line is to have a high productivity, good quality and low cost and to ensure smoothness of the production line. The main problem at production line is the usage of the conveyer where it can make the space become crowded. The proposed method is by changing to cell manufacturing layout because it is way of lean manufacturing to guide company to implement less waste as possible for product variety to the customers. The objective of this project is to investigate current performance of coil winding assembly and to model and simulate flexible production line using Pro Model simulation software. In this case study, the framework of project will cover on research of cycle time, product mix, flexibility and efficient usage of space. A company has been selected is Vacuumschmelze(M) Sdn Bhd and simulation ProModel 7.0 Software Student Version was used to complete the case. The project is begin by identifying and evaluating the problem occur at the production line. The current condition of production line layout was modelled using simulation ProModel 7.0 Software Student Version. The simulation was run in 8 hours by following the working schedule at company. A total of 10 replication has been set for this project. From the result, the percentage show high utilization from the current performance. The percentage of operation is increase from 9.29% to 63.27%. From the result, it can be concluded that the changing of the new layout by changing the conveyer to the U-shape layout was the most significant factor in productivity enhancement of the production.

## ABSTRAK

Tesis ini membincangkan pemodelan dan simulasi barisan pengeluaran fleksibel untuk pemasangan gegelung penggulungan. Pengeluaran fleksibel ialah barisan pengeluaran yang mampu untuk mengubah perubahan dalam produk yang berbeza pada masa yang sama dan berterusan. Faktor keperluan membangunkan pengeluaran fleksibel adalah untuk mempunyai produktiviti yang tinggi, kualiti yang baik dan kos rendah dan memastikan kelancaran barisan pengeluaran. Dalam kajian kes ini, rangka kerja projek akan meliputi penyelidikan masa kitaran, pelbagai produk, fleksibiliti dan keberkesanan penggunaan ruang. Masalah utama di barisan pengeluaran adalah penggunaan konveyer di mana ia boleh membuat ruang menjadi sesak. Kaedah yang dicadangkan adalah dengan mengubah kepada sel susun atur pembuatan kerana ia adalah cara pengurusan (lean) untuk membimbing syarikat dalam melaksanakan sekurang yang mungkin untuk variasi produk kepada pelanggan. Objektif projek ini adalah untuk menyiasat keadaan semasa pemasangan gegelung penggulungan dan membuat pemodelan dan simulasi pengeluaran fleksibel menggunakan perisian ProModel. Berdasarkan tajuk projek, syarikat telah dipilih iaitu Vacuumschmelze (M) Sdn Bhd dan simulasi ProModel 7.0 Perisian Pelajar Versi telah digunakan untuk menyelesaikan kes itu. Projek ini bermula dengan mengenal pasti dan menilai masalah yang berlaku pada barisan pengeluaran. Keadaan semasa susun atur barisan pengeluaran telah dimodelkan menggunakan simulasi ProModel 7.0 Perisian Pelajar Version. Simulasi yang telah dijalankan selama 8 jam dengan mengikuti jadual kerja di syarikat. Sebanyak 10 replikasi telah ditetapkan untuk projek ini. Daripada keputusan itu, peratusan menunjukkan penggunaan tinggi daripada prestasi semasa. Peratusan operasi adalah peningkatan daripada 9.29% kepada 63.27%. Dari penilaian, dapat disimpulkan bahawa perubahan susun atur yang baru dengan menukar konveyer kepada susun atur bentuk U adalah faktor yang paling penting dalam meningkatkan produktiviti pengeluaran.

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**LIST OF ABBREVIATIONS**

FYP	Final Year Project
WIP	Work in Progress/Work in Process
MNC	Multi National Company

**LIST OF SYMBOLS**

$\bar{x}, \mu$	Mean
$\sigma$	Standard deviation
$\Sigma$	Sum/ Total
$hw$	Half-width

## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 INTRODUCTION**

This chapter describes more on modeling and simulation of flexible production line for coil winding assembly and the importance of flexible production line in the industry. In addition, the background of company, project background, objective and scope of the study including in this section.

#### **1.2 BACKGROUND STUDY**

In this rapid development, the area of flexibility can be considered as the main issue for surviving today's demand which can be described as high productivity, shorter lead times, good quality, low cost and continuous evolution of the technological requirement of the product. The greater number variation of new models, fluctuation in the market demand refers as some problem need to face on the flexibility system. Even flexibility can be identify as a crucial strategic option which must consider as the competitiveness of a firm can be strongly affected by the burden of capital intensive investment in flexibility system. For that reason, there is the need of viewing flexibility system in the global image trying to consider both pros and cons related to the acquisition of flexibility.



### 1.3 PROBLEM STATEMENT

With the faster development of modern industry, the scale of the production became more expanding and it is proposed higher requirement for the process and production management system. Flexibility refer to ease physically rearrange the cell. It is necessary of production manufacturing system have to be flexible to adapt more faster to an increasing number and variety product and changing market volumes. The ideal condition is the flexible production line can be cater in term of volume fluctuation and product mix.

However, the concepts of classical assembly line are difficult to control utilization when producing part with different processing at same line. (Krajewaski *et al.*, 2010). This is support by the current condition at Vacuumschmelze (M) Sdn Bhd. The problem involve of conveyer usage. So that, it will give an impact to the spaces of the production line where can increase the work in progress (WIP) and bottleneck

In order to develop competitive organization, the production system must along with to be lean and flexible to achieve constant development. As the proposed solution to this project, cell manufacturing layout will be applied. This is supported by journal from Ogan & Azizoglu (2015), the need for higher productivity with greater flexibility has advocated the need for the U-shaped lines. The method approach in this case by using ProModel simulation software. According to the Villarreal & Alanis (2011), the uses of simulator such as ProModel, Witness and others have facilitated enormously the application of simulation to the design, improvement and validation of system in a wide area of knowledge.

## 1.4 OBJECTIVE

The objectives of this study are stated as below:

1. To investigate current performance of coil winding assembly.
2. To model and simulate the flexible production line using ProModel Software.

## 1.5 PROJECT SCOPE

The scope of project is mainly about on modeling and simulates the real production process. The research will be conducted in manufacturing company focused on Multinational Company (MNC) in Malaysia context. The project was conducted at Vacuumschmelze (M) Sdn Bhd. This company located at Lot 3465, Tanah Putih, 26600 Pekan Pahang. Basically, Vacuumschmelze is a leading global manufacturer of advanced material and related products. The early beginning of Vacuumschmelze (M) Sdn Bhd is transferring labor – intensive manufacturing processes to more cost effective countries. Since 1980's, VAC maintained the production facilities in Asia. Nowadays, VAC becomes well established in production network in Europe and Asia, which is optimized and best-suited for each product group. Generally, this company produced mixed model product at the production line. The variation of the model is depending on scheduling and demands from customer. The straight line layout was used and apply conveyer. The coil winding model was investigated in this project are 6161-X037 and 6161-X001 and ProModel 7.0 Student version was used in running the simulation



**Figure 1.1:** Vacuumschmelze (M) Sdn Bhd

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 INTRODUCTION**

This section presents on literature review of flexible production line in producing coil by using simulation study. The explanation was started by elaborate on the definition of flexible production system and flexible production line. Other than that, modeling and simulation using ProModel were described including the advantages and disadvantages.

#### **2.2 FLEXIBLE PRODUCTION SYSTEM**

In the fastest development of market framework, the demand from customer and more specific of product changes very fast, so it is crucial for a manufacturing system to carry on the changes as faster as possible to be able face the opposition in the market. From the effect of the shorter product life cycles and the arising of the product variety, the manufacturing industry faces biggest challenges in concerning the satisfaction of the customer demand. Due to the growing dynamic and variation in demand modern production systems have to be lean and flexible in order to strengthen the company's competitive position (Metternich, Böllhoff, Seifermann, & Beck, 2013). Flexible production system informs that the requirement from custom-made products is currently in main point. The expenditure of the ability must not design for the flexible and expandable manufacturing system to accomplish the efficient cost in large scale of production. From this it can able to exclude equal cycle times while support a smoothly running process. It can be achieve by an appropriate operations stepping onto specific

configuration of work stations and a control system which can monitor in good configurability of systems and distribution.

### **2.2.1 Production Line**

Production line is a series of arranged workstations where the product moves from one station to the next, and at each location a part of the total work is performed on it (Groover, 2010). The term production line is used to describe systems for discrete manufacturing and includes all of the equipment required for an independent segment of production on discrete objects. The examples include segments that assemble, package, fill, or test products as they move through the production line. There is often storage before and after production lines used to buffer material due to different rates of production. Major production lines are made up of work cells, which correspond to locations where specifically identified operations are performed on products.

Basically there are two main types of production line. The first type of production line is where every product is identical. While the second type of production line is the mixed-model production line. This type of production line applies to the situations where there is soft variety in the product made on the line (Rakiman & Bon, 2013). A production line layout can be considered to be a common and very efficient way to manufacture a product. Generally, the industry need or required flexibility in response and also a high quality standard which need to have led to the rapid development of automated flexible machines. These machines are able to perform in sequence of different operations which are commonly combined in automated flexible production line as a replacement for traditional manual or hard automation based on workstations.(Kalir & Arzi, 1998).

### **2.2.2 Flexibility**

Flexibility is defined as ‘capable of responding or conforming to changing or new situations’ based on Webster’s Dictionary. It also can be refer as to ease of physically rearranging the cell. The term flexibility also meets the meaning of the potential of producing variety of parts out of use of major retooling. The scope includes the converting process from making the old lines of output to new outputs. Besides that, the flexibility meets the ability to alternate part or multiple parts and transforms a production schedule. In the area of manufacturing system, there are several definitions for flexibility which includes; parts flexibility, volume flexibility and mix flexibility (Gerwin, 1982).

- i. Parts flexibility: Used to add parts and remove parts from the mix over time.
- ii. Volume flexibility: Ability to change the volume level and conduct shifts in volume of given part to ensure profits and minimal interruptions.
- iii. Mix flexibility: It can be process at any time that associates or combine various parts which are almost related to each other that belong to the same family

## **2.3 ASSEMBLY LINE**

The assembly line can be referring as manufacturing process where which interchangeable parts are added to a product in a sequential manner to create an end product. Normally the assembly line made can be classified as semi-automated system through which a product moves. At each station along the line some part of the production process takes place. The workers and machinery used to produce the item are stationary along the line and the product moves through the cycle, from start to finish. The traditional assembly line concepts struggle to maintain high utilization when producing components with high variances in processing times at the same line.(Greschke, Schönemann, Thiede, & Herrmann, 2014).

### **2.3.1 Mixed Model Assembly Line**

The mixed-model assembly lines are a manual production line capable of producing a variety of different product model simultaneously or continuously. Each workstation specializes in a certain set of assembly work elements, but the stations are sufficiently flexible that they can perform their respective task on different models. It can allow the simultaneous assembly of a set of products on a single assembly line. The vary models of products could be parts of a base product or constitute a special package of products, so inherently their assembly process is somehow similar and assembly models mostly differ in performance times. (Ramezani & Ezzatpanah, 2015).

## **2.4 PLANT LAYOUT**

Basically with the capital-intensive nature of manufacturing systems, plant layout is important to the smooth flow of product and movement of resources through the facility. A good layout results in a streamlined flow with minimal movement and thus minimizes material handling and storage costs. In deciding which layout to use will depend largely on the variety and lot size part produced that are produced. If the variety of parts is similar enough in processing requirement to allow grouping into part families, a cell layout is best.

### **2.4.1 Cell Manufacturing Approach**

Cell manufacturing can be refer as a way of lean manufacturing to guide company in implement as less waste as possible for product variety to the customers. The arrangement of equipment and workstation is arranged in sequence which can ensure the material flow with minimum transport or delay and component part going smoothness in their process. In this stage, recognize and understand the present condition to identify the process need to convert. Firstly is collecting the data of mixed model, production resources, process time, takt time and standard work combination worksheet. In this stage for mixed choose what are the process needs to be converted to a cell. It will make easier if the company produce few type of product in relatively large

volume. A large volume process will give more on advantage from the improvement and low variety will keep away on issues such as changeover. Normally the production resources need to be taken. It will involve gathering the information in production resources to analyze the mixed product such shift day, hours per shift; break time, work days/month, employee to the operation ratio, product volume in monthly which required from customer, approach for assigning work and finished goods inventory turns per months.

The processing time is necessary by examine the time elements which involve in production by doing the time observation. The first task will observe by measuring the cycle time for each machine operation in the process. The task will include writes the tasks for one complete machine cycle on the left side of a Time Observation Sheet. The example task will take in cycle is loading and unloading, opening and closing machine guards, and other human and machine actions. The time required for each task during cycles and finds the average of cycle time. The next process is identifying the sample of process lead time for the total process. Finally identify the value-added ratio. This can be refer as the time spent actually in machining or working on the product divided by the total process lead times.

Next, process capacity used to calculate the units operation can be produce in given time for example shift or day. From here, we can see the walking time each activity. The takt time is rate at which each product needs to be completed to meet daily customer requirements the need to be determine for the process. It can be done by divide the work time in daily by the required quantity daily. The units expressed in second or minutes per units. For the final step, prepare Standard Work Combination Sheet for each operation in the process. The sheet is a graphic display of the relationship between manual work time, machine work time, and walking time for each step in an operation.

$$\text{Takt time} = \frac{\text{Daily Work Time}}{\text{Daily Required Quantity}} \quad (1)$$

## 2.5 MODELLING AND SIMULATION

Generally, simulation, modeling and analysis of manufacturing systems to improve the performance have become increasingly important during the last few decades. Simulation has been used for decades as a tool to support decision making in manufacturing systems. It is far cheaper and faster to build a virtual system and experiment with different scenarios and decisions before actually implementing the system. Simulation has been widely used to support decisions in both manufacturing systems design and operation (Seleim, Azab, & AlGeddawy, 2012). Simulation is the imitation of a dynamic system using a computer model in order to evaluate and improve system performance. Modern computer aided simulation and modeling tools help to visualize, analyze and optimize complex production processes using computer animations within a reasonable amount of time and investment (Sandanayake, Oduoza, & Proverbs, 2008). In this project, the ProModel 7.0 student version was used to simulate the flexible production line. Basically, ProModel simulation software is a simulation and animation tool designed to quickly yet accurately model manufacturing systems of all types, particularly supply chains systems.

### 2.5.1 Building a Model

ProModel is a powerful, easy to use, commercial simulation package which designed to effectively model any discrete-event processing system. A model can be explained in ProModel using simple graphical tools; data entry tables, and fill in the blank dialog boxes. It consist of entities (the item being processed), locations (the place where processing occurs), resources (agents used to process and move entities and move traverse), and path (aisle and pathways along which entities and resources traverse). Dialogs are associated with each of these modeling elements for defining operational behavior such as entity arrivals and processing logic. Schedules, downtimes and other attributes can also be defined for entities, resources, and locations.

The elements of the system are defined graphically in ProModel (See figure 2.1). A graphic representing a location, for example, is placed on the layout to create a new location in the model. Some information can be input in this location such as name, capacity, etc. Default values are provided to help simplify this process. Defining objects